WATER MANAGEMENT IN ALBERTA

CHALLENGES FOR THE FUTURE

BACKGROUND PAPER

VOLUME 1

ALBERTA'S WATER RESOURCE

Alberta
ENVIRONMENT

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SUMMARY

VOLUME 1: ALBERTA'S WATER RESOURCE

CHAPTER 1: WATER IN ALBERTA

Water is Alberta's most important renewable natural resource. Volume one explains the hydrologic cycle and the distribution of water in this province as a basis to understanding the issues about this resource.

Alberta has a good supply of surface water; however, variations in geography, climate, and the hydrologic cycle create regions of scarcity. the amount of annual runoff and seasonal changes account for further variation.

In addition to the sources of surface water, groundwater is an important component of Alberta's water resource. Practically every part of the province has groundwater but aquifer depths, yields, and water potability vary. Aquifer discharge establishes the base flow of many rivers and streams, sustaining them during winter and other dry periods.

There are five main water withdrawal (consumptive) uses in Alberta: agricultural, thermal power, municipal, industrial and water injection. Hydro power production is a significant but non-consumptive use of water. Instream uses include fisheries, recreation and effluent dilution. As increased water withdrawal occurs, particularly in southern rivers, water quality becomes more important in defining water management issues.

Managing and licensing water in Alberta is complex because of the variation in water supply and the demands for this supply. Measuring the quantity and quality of water generated in or flowing through Alberta is essential to plan, develop, and manage the water resources projects. By using a variety of water data collection networks, the needs of water quantity and quality for Albertans can be planned for and met.

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Units of Measurement

1 km = 0.621 mi.
1 km^2 = 0.386 $mi.^2$
1 km^2 = 247 acres
1 dam^3 = 0.81 acre-ft.
1 dam^3 = 1000 m.3
1 dam^3 = 1 cubic decameter
1 metre = 3.28 feet
1 m^3/sec = 35.3 ft^3/sec.
1 litre = 0.22 imperial gallons
1 litre/min = 0.000589 ft^3/sec.

SET OF MAPS WHICH WILL BE FOUND

IN AN ENVELOPE ATTACHED TO THE BACK COVER

FIGURE 5	- BURIED CHANNELS
FIGURE 7	- HYDROMETRIC NETWORK
FIGURE 8	- TELEMETRY NETWORK
FIGURE 10	- OBSERVATION WELL AND PIEZOMETER NETWORK

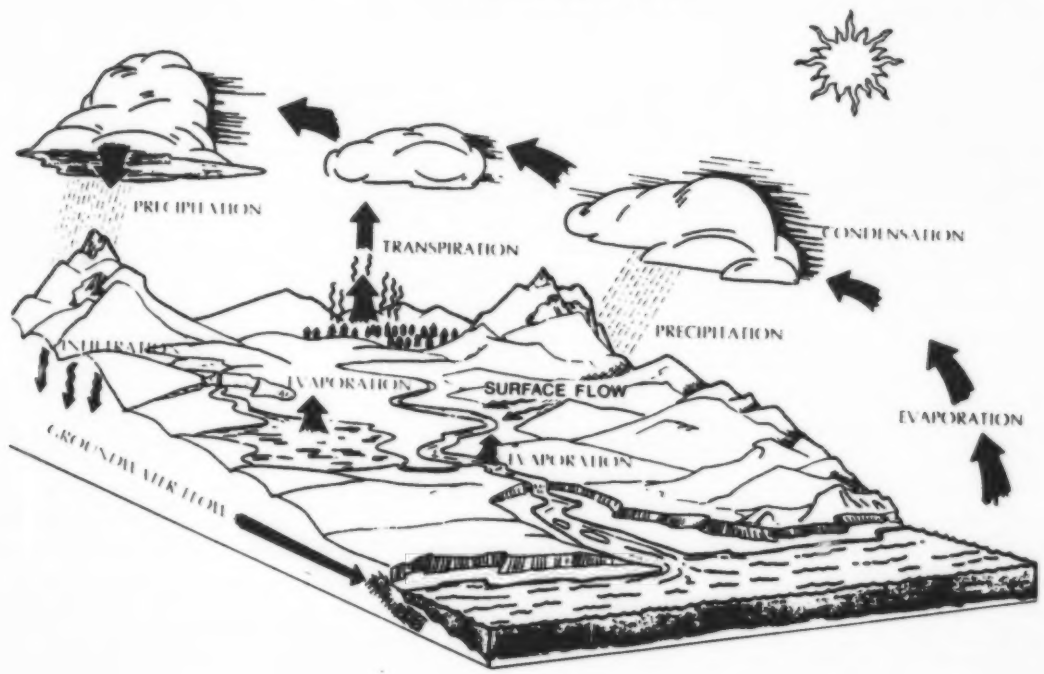
ALBERTA'S WATER RESOURCE

Introduction

Of all the renewable natural resources in Alberta, water is the most important; it is the most basic requirement needed for survival by all living things. For this reason we must understand how water is generated so that this valuable resource can be measured, studied and properly managed.

Water is constantly in motion. Falling from the atmosphere as rain or snow or dew, it runs over the land surface, infiltrates through soils and rock underground and moves through rivers and lakes, eventually returning to the ocean. During this movement, surface water evaporates and water used by plants transpires into the atmosphere as vapour, condenses into clouds and falls again as precipitation. This constant movement of water is called the hydrologic cycle.

FIGURE 1. THE HYDROLOGIC CYCLE



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Water Availability

Alberta is fortunate in its abundant supply of fresh water, but the geographical variation in this resource has created regions of scarcity. Northern regions of Alberta are the wettest. The majority of Alberta's water is generated in the Peace River system and flows northward through the Slave River. In contrast, in the south, where water use is highest, the least amount is available.

The map displayed in Figure 2 presents the mean annual flows of major rivers at Alberta's boundaries and also gives a quick visual impression of the total flow in our river systems. River line widths are directly proportional to the mean annual flow of the various rivers shown.

This variation in flow is a result of three factors:

- the size of drainage basin (eg. the Peace River Basin encompasses nearly 44% of the total area of Alberta).
- the location of headwater systems (the mountains and foothills receive more precipitation than do the plains).
- the variation in climate (temperature is higher and evaporation greater in southeastern Alberta than in northern and western regions).

For example, the average annual precipitation ranges from about 250 mm (10 inches) in the area north of Medicine Hat to 1500 mm (60 inches) in the high mountain country.

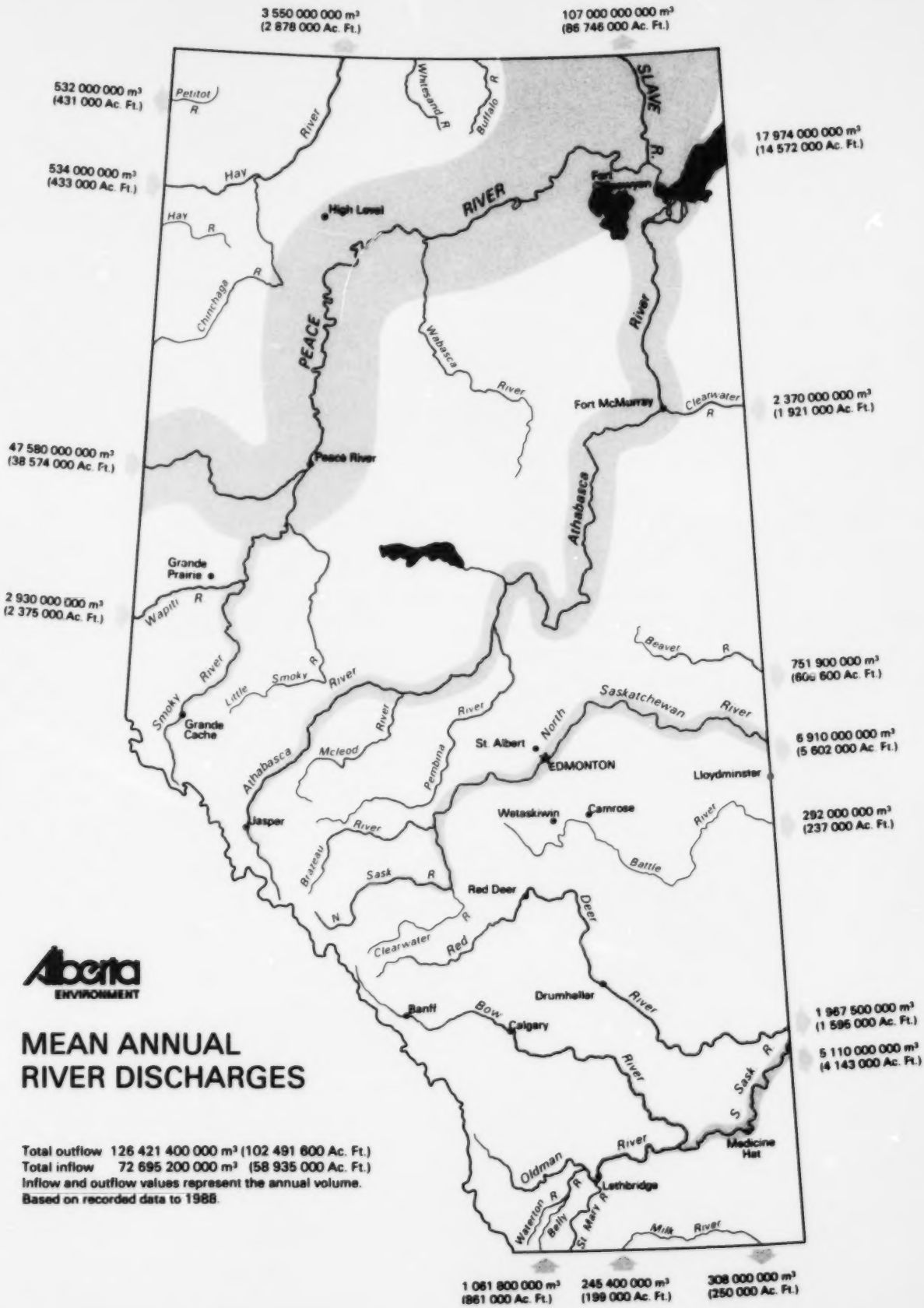
Water Supply Variability

Another factor affecting water supply is the variability resulting from yearly and seasonal differences in weather.

Total annual runoff from the high mountain regions varies little from year to year. Figures for the Bow River at Banff show a tight range from about 900,000 dam^3 (cubic decameters) in 1949 to 1,600,00 dam^3 in 1954. In contrast, total annual flow in the Battle River at Ponoka, a central plains stream, has ranged from 15,000 dam^3 in 1976 to 260,000 dam^3 in 1927. Located midway between these two, the Red Deer River, at Red Deer, which rises on the eastern slopes of the Rocky Mountains, has experienced a variation in total annual flow volume from less than 700,000 dam^3 in 1949 to almost 4,000,000 dam^3 in 1915.

An even greater extreme in annual water supply occurs in the southeastern part of the province. Ross Creek, flowing from the Cypress Hills through Medicine Hat to the South Saskatchewan River, has recorded a variation from year to year ranging from practically nothing to 25,000 dam^3. This illustrates a critical water supply licensing problem in this basin where 500 water users have already been licensed to withdraw 67% of the estimated mean annual flow volume. Obviously there have been many years when the desired water supply simply has not been available.

Seasonal variations also affect water supply. Spring melt and summer rains produce the great volumes of flow while drier fall weather and temporary storage of water in snow and ice during winter are reflected in low runoff patterns. This seasonal change in surface water flow varies across the province (Figure 11). Mountain-fed streams such as the Bow River generally experience greatest flows in June or July during the mountain snow melt



Alberta
ENVIRONMENT

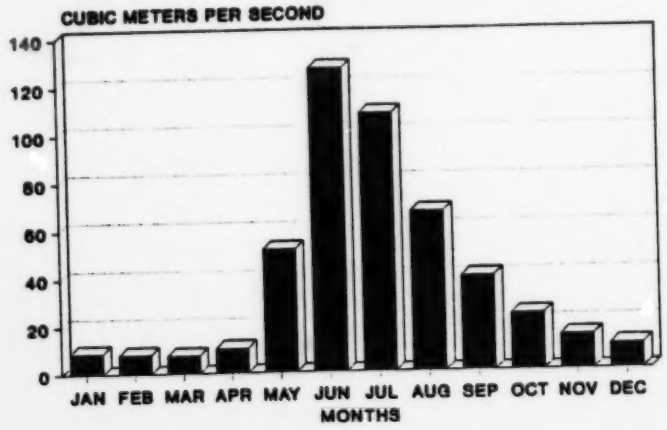
MEAN ANNUAL RIVER DISCHARGES

Total outflow 126 421 400 000 m³ (102 491 600 Ac. Ft.)
Total inflow 72 695 200 000 m³ (58 935 000 Ac. Ft.)
Inflow and outflow values represent the annual volume.
Based on recorded data to 1988.

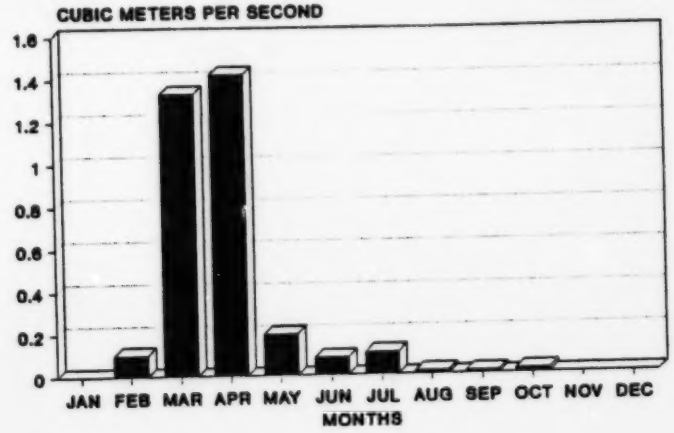
Water Resources Management Services — Revised March 1991

FIGURE 2

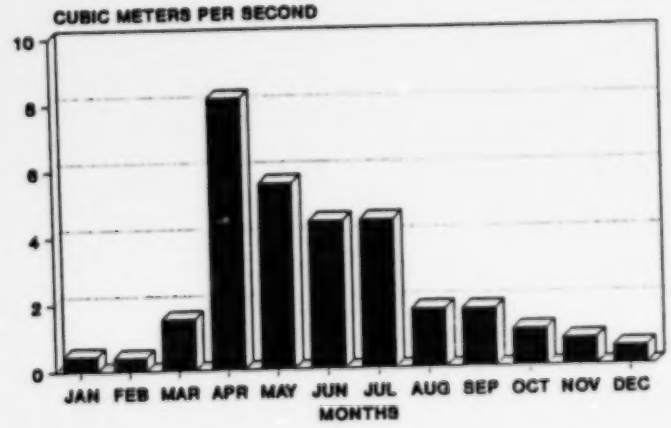
BOW RIVER AT BANFF
MEAN MONTHLY DISCHARGE (1911 TO 1988)



WEST ARROWWOOD CREEK NEAR ARROWWOOD
MEAN MONTHLY DISCHARGE (1965 TO 1988)



BATTLE RIVER NEAR PONOKA
MEAN MONTHLY DISCHARGE (1913-32,1966-88)



SOUNDING CREEK NEAR OYEN
MEAN MONTHLY DISCHARGE (1968 TO 1988)

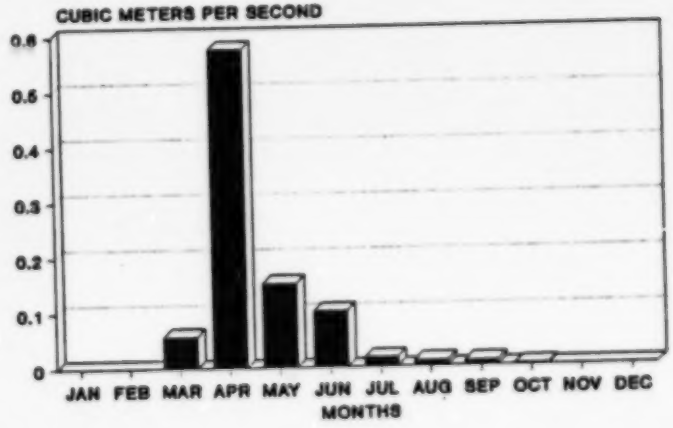


FIGURE 3. SEASONAL FLOW PATTERNS

period, while streams located in the plains usually peak in April. The Battle River is an example of the latter. The West Arrowwood and Sounding Creeks respond almost entirely to an early spring melt.

The Pembina River peaks in April due to snow melt and then responds to rainfall by peaking again as late as June or even July. Large runoff events which are caused by heavy rainfall have also occurred on this river in August. The historical record from 1970 - 1989 shows both seasonal and annual variations on the Pembina River (Figure 4)

Groundwater

Where surface water sources are not readily accessible, groundwater resources are of particular importance. It is estimated that the total volume of potable groundwater in this province may approach 5.5 billion dam^3 with a recoverable, sustainable volume of 16,000,000 dam^3, an amount nearly equal to the total volume of Cold Lake.

Groundwater is retrieved from permeable deposits such as sand, gravel or sandstone. Some groundwater can be found in practically every part of the province but aquifer depths, yields and water potability vary. Yields for individual wells in tight rock formations can be less than 2 litres/minute. On the other hand, buried channels (aquifers found in the buried sands and gravels of ancient river beds) generally have an excellent yield. Buried channels having a combined length of 16,000 km have been identified and partially mapped in Alberta (Figure 5). Water yields from these channels can be as high as 25,000 litres/minute.

Alberta's groundwater resource is not as well-defined as that of its surface water. Documentation of water quality, yields, water volumes and depths of producing zones is a slow process because of the high cost of exploration. The locations of a number of major aquifers in the province are reasonably well known, however, and regional data are being accumulated and compiled into hydrogeologic maps and reports as the number of water wells and exploration programs expands.

Groundwater is an integral part of the hydrological environment. It is a dynamic component subject to sub-surface flow and eventual discharge to surface water systems. Aquifer discharge is the base flow of many rivers and streams, sustaining them during winter and rainless periods. Overdevelopment of groundwater resources could result in reduced flow from groundwater discharge areas. Such change could lead to the degradation of wetlands and alteration of surface runoff characteristics, as well as to the alteration of flow paths to the extent that water quality characteristics are changed (e.g., induced intrusion of salty groundwater into a freshwater environment). Conversely, some part of the surface streamflow as well as lakes and wetlands may replenish aquifers. Surface water developments such as reservoirs have the potential to add additional water to aquifer systems, thus contributing to higher water tables beyond their immediate vicinity.

Water Use

Aside from hydro power production (a very significant but non-consumptive use) there are five main water withdrawal (consumptive) uses in Alberta: agricultural, thermal power, municipal, industrial and water injection (Figure 6). In addition there are instream uses other than hydro which include fisheries, recreation and effluent dilution, the latter directly related to water quality.

The total amount of water withdrawn by users is not fully consumed; some, such as sewage effluent, irrigation return flow and thermal cooling water is returned to the natural drainage system. For example, the total amount of surface water withdrawn by major water users in Alberta in 1989 was approximately 4.7 million dam^3, while the total volume consumed was 2.6 million dam^3. The irrigation industry is the largest user by far.

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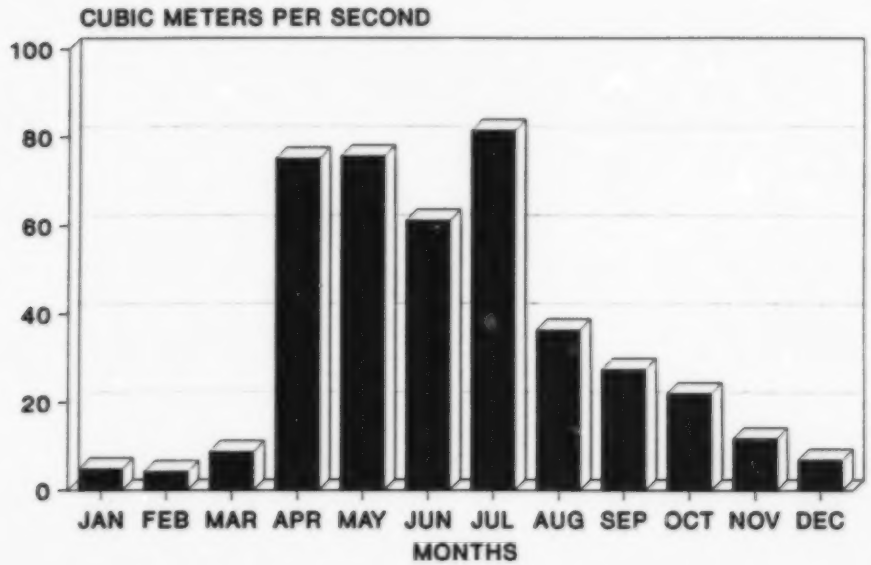
PEMBINA RIVER AT JARVIE
MEAN MONTHLY DISCHARGE (1957 TO 1988)



PEMBINA RIVER AT JARVIE
ANNUAL VARIATION IN MEAN MONTHLY FLOWS

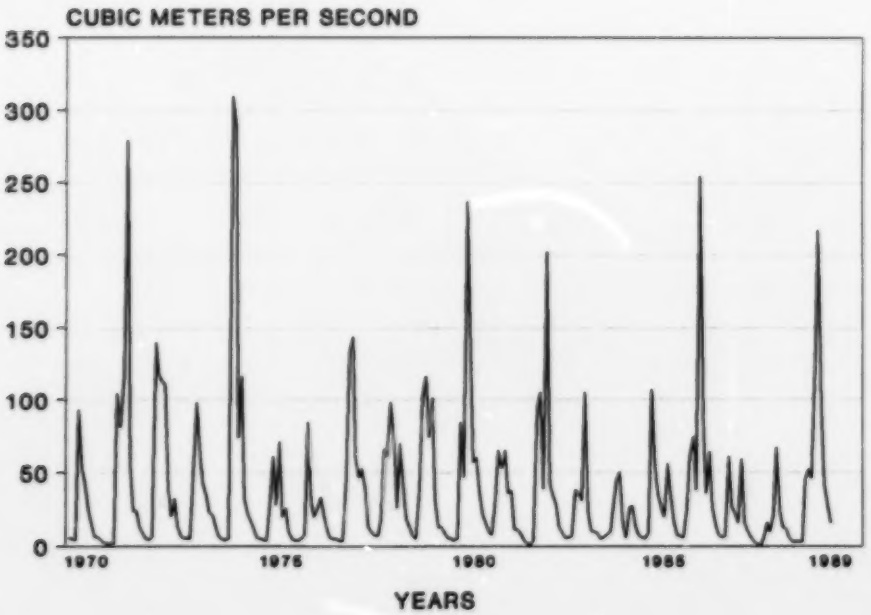
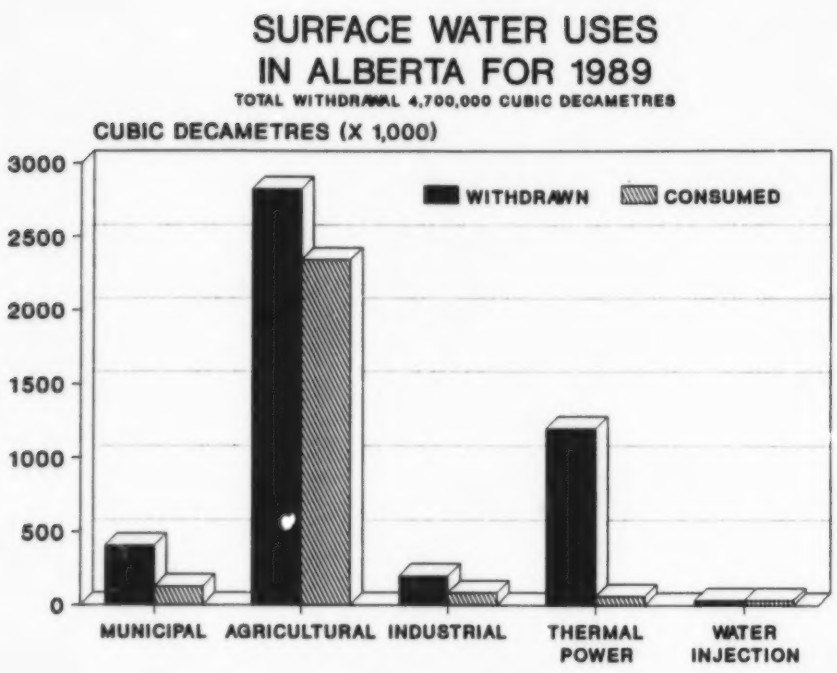


FIGURE 4. PEMBINA RIVER HYDROGRAPHS



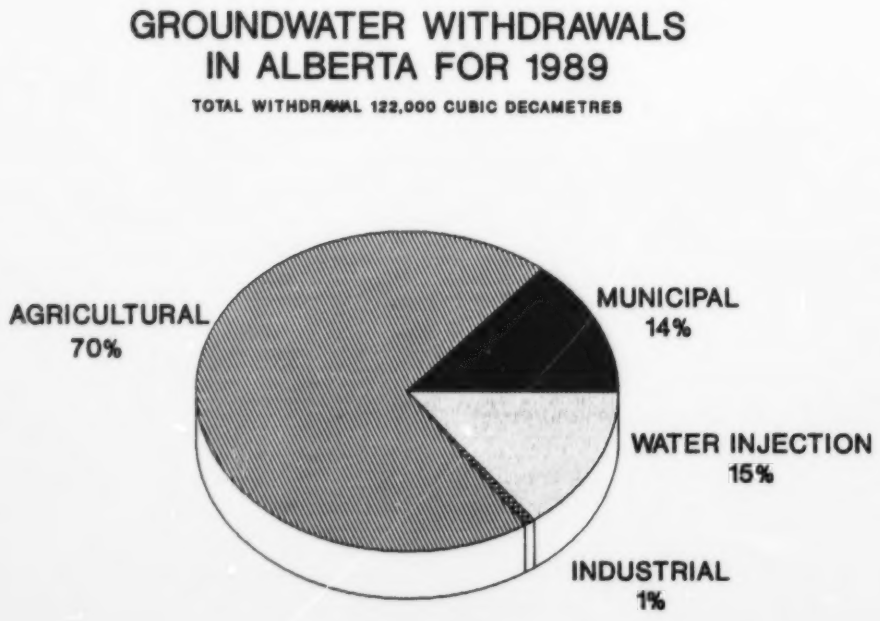


FIGURE 6. WATER USE IN ALBERTA

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In 1989, 93% of this irrigation water was withdrawn from only two sources, the Bow and Oldman River systems.

Of all the water currently withdrawn in Alberta, only about 3% comes from the groundwater system. However, this relatively small volume is of vital importance, since a great many Albertans depend upon groundwater for their domestic water supply. Currently there are approximately 500,000 domestic wells in the province and about 7,000 are added each year.

Water Quality

Surface Water

As water demand increases, water quality becomes more prominent in defining water management issues. River flows determine instream temperature and oxygen regimes important to fish and other aquatic life. Particularly for southern rivers in summer and in all rivers during winter, instream water quality can deteriorate because of low flow periods. Dilution of municipal and industrial wastes is reduced at these times. For the Bow, Red Deer and North Saskatchewan river systems, upstream storage reservoirs have helped water quality by augmenting river flows during natural low flow periods.

From the Red Deer River south, licensed water withdrawal adds a second dimension to the management of water quality. These river systems are less turbid, and have a heavier nutrient loading. Recently steps have been taken to reduce or remove industrial discharges into rivers, but below each major city, municipal discharges still have an impact. During summer in early morning hours, these discharges cause a significant dissolved oxygen sag which may affect fish and invertebrates.

By comparison, the northern systems (Peace and Athabasca) are much larger and are not subjected to significant water withdrawals. These rivers tend to be deeper, cooler, more turbid and biologically less productive. The major water quality issues are associated with the discharges of industrial and municipal effluents, which are regulated by a system of licenses and permits.

Seasonal patterns of river discharge, in particular low winter flows coupled with ice-cover, dictate specific management approaches which have focused recently on the maintenance of minimum winter dissolved oxygen concentrations. The Peace River is regulated by the WAC Bennett dam in British Columbia and Alberta is negotiating guaranteed instream flows with B.C. to protect water quality and other uses. River water quality management is progressing from a system based on available treatment technology to one based on receiving water conditions.

Groundwater

The useable volume of water from underground sources is limited by its quality. In general, only groundwater within 400m of the surface is suitable for domestic consumption or industrial use. Below this depth, water quality deteriorates because of increasing concentrations of dissolved minerals. The base of the useable groundwater zone is only approximately known, because the boundary between potable water in the upper zone and highly mineralized water at a lower depth changes. The depth of this boundary is further dependent upon geology, topography, and the direction of groundwater flow.

Protection of groundwater resources in the useable zone is of vital importance. Land uses or industrial practices having the potential to cause a deterioration in groundwater quality include application of agricultural chemicals,

industrial plants, liquid and solid waste disposal or storage sites, and oil and gas exploration and development activities.

Groundwater recharge areas (those areas where surface water directly infiltrates through overlying geologic deposits to replenish groundwater resources) are particularly sensitive to contamination. Many types of groundwater recharge areas are distributed throughout the province, and their sensitivity varies depending upon local hydrogeologic conditions. Identification and classification of recharge areas is a continuous process dependent upon the accumulation and interpretation of drilling and well completion information as well as other hydrogeological data.

Information Needs

If the province always had enough water where it was needed, and if floods never occurred, planning, controlling, managing and licensing would be simple. But, of course, that is not the case. The very real circumstances are extreme variability in water supply, water demand exceeding water supply in the dry areas, periodic flooding, excess surface water in some agricultural areas, uncertain groundwater yield in many places, and increasing water quality concerns. To this list of problems is added the responsibility Alberta must assume as custodian of the headwaters of the Saskatchewan River system and a good portion of the Slave River system. Alberta needs to define and to understand its water resource.

Measuring the quantity and quality of water generated in or flowing through Alberta is essential. This information is needed to plan, develop, and manage water resources projects for water supply, irrigation, hydroelectric power generation or flood control, to satisfy instream flow needs and interprovincial/international agreements for water sharing, to forecast floods, to monitor water quality and control industrial pollution, and to supplement other essential measurements that relate to erosion and flood protection.

Data Networks

The measurement of water in Alberta is done through the operation of a variety of water data collection networks: hydrometric, snow survey, meteorologic, telemetry, groundwater and water quality.

A hydrometric network (Figure 7 - see folder in back cover) has been established to measure streamflow, lake levels and sediment data. This basic long-term network consists of a total of 525 recording stations that are operated co-operatively under the terms of a federal/provincial cost-sharing agreement with Environment Canada. Sediment data are collected at 54 of the streamflow stations. Alberta Environment also operates 124 short-term miscellaneous streamflow and 250 lake level stations.

A special meteorological network has been established to collect climate data such as precipitation, temperature, wind speed, and solar radiation. This network of 117 climate stations is also operated in a co-operative arrangement with Environment Canada. Supplementary to this, a snow survey network is in place to measure the depth and water content of snow cover. These measurements are essential for estimating runoff potential and its probable effect on spring floods, as well as for giving a good indication of water availability during the summer.

The real time telemetry network used by Alberta Environment (Figure 8 - see folder in back cover) provides water measurements instantly from both hydrometric and meteorological recording sites. A variety of recording devices and sensors are employed. The primary systems for the data transmission are satellite and telephone lines. Since these measurements are transmitted as they are made, they are referred to as "real time" data. These data are available from 151 hydrometric and 56 meteorological sites, which are part of the federal/provincial hydrometerological networks in Alberta and adjacent provinces and states. The data are used primarily for flood

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forecasting. A secondary purpose is for determining how much water should be stored in or released from provincial reservoirs.

Alberta Environment has made a major contribution to the growth of the telemetry network. Figure 9 shows the increase in the number of weather and streamflow stations where Alberta Environment has supplied and continues to maintain telemetry equipment.

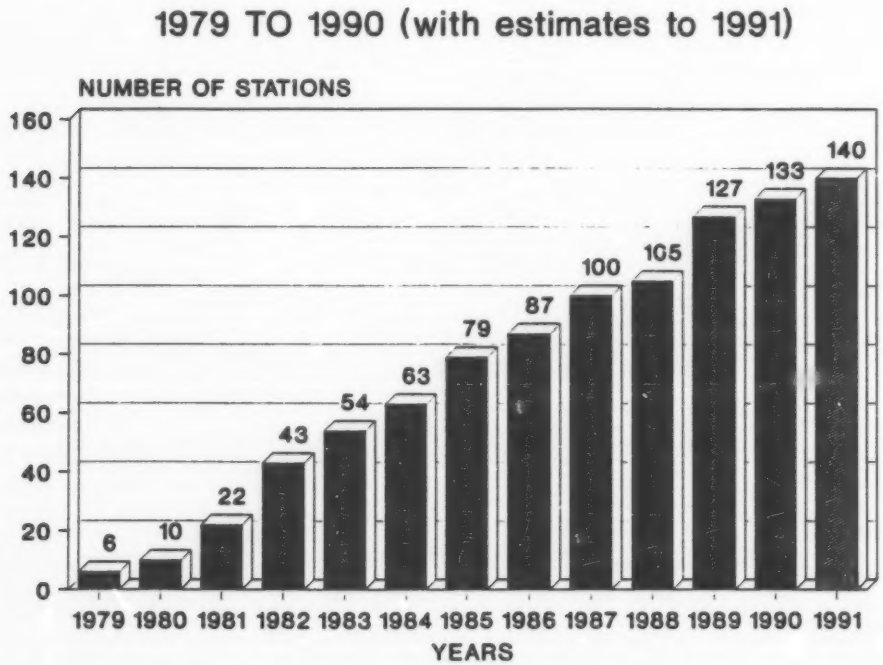

FIGURE 9. ALBERTA ENVIRONMENT TELEMETRY NETWORK

A province-wide groundwater observation well network (Figure 10) has been established to monitor water levels and water quality in aquifers that have a potential to be used for water supply purposes. This network consists of 340 observation wells, ranging in depth from six to 240 metres and 200 piezometers (small diameter wells). In addition, groundwater is also monitored in the vicinity of reservoirs, rivers, lakes, dams and oil sand developments to determine impacts on local groundwater systems.

Another monitoring program which supplements streamflow measurements during a flood and provides a record of the extent of flooding is Alberta Environment's high water-mark data collection program. This field activity, together with aerial photography, is used to record the extent of large floods. Data collected are useful in many different types of water management projects and in the study of basic features of river channels. The analysis of this data helps solve erosion, sedimentation and flooding problems.

Ambient water quality is monitored monthly at 13 river and 4 lake sites to establish long-term trends (Figure 11). Additionally, some 500 river water samples and 550 biota samples are taken annually to evaluate specific issues.

Municipal water supplies and sewage effluent are monitored in about 1500 raw water and 250 treated water samples per year from 50 Alberta communities. Monitoring of industrial effluents by Government generates 500 samples in addition to the monitoring which industries do as part of their license requirements.

Special water quality problems are being addressed within rivers with a network of 12 - 15 robot monitors which routinely track important information such as oxygen and temperature. These systems, which are often closely linked to river flow monitoring (hydrometric) sites, have been effective in providing real time information on the Athabasca River in winter, and the Highwood River in summer.

Alberta Environment

Alberta Environment is committed to achieving the protection, improvement and wise use of our environment now and into the future. Our quality of life depends on the proper understanding and management of our water resources. Alberta Environment is responsible for developing and maintaining monitoring networks to ensure that necessary information will always be available for management of the province's water resources.

GLOSSARY OF TERMS

Ambient	surrounding
Aquifer	an underground geologic formation of permeable rock, sand or gravel that is capable of yielding a significant amount of groundwater to a well or spring.
Biota	All plant and animal species occurring in a specified area.
Dam^3	a metric measure of a volume of water equivalent to 1000 metres^3 or about 200,000 gallons.
Effluent dilution	The dilution of industrial and municipal discharges which occurs in receiving water courses.
Piezometer	Observation well constructed for the purpose of obtaining measurements of the water table level, that is, the level to which water would rise in a groundwater well.
Potable	Fit for drinking.
Telemetry	The process of transmitting data electronically, directly from a remote site to a central computing centre. The data may be transmitted by telephone line or by radio or satellite relay systems.
Turbid	Opaque with suspended matter. Water with conspicuous amounts of mud, silt or algae is said to e turbid.

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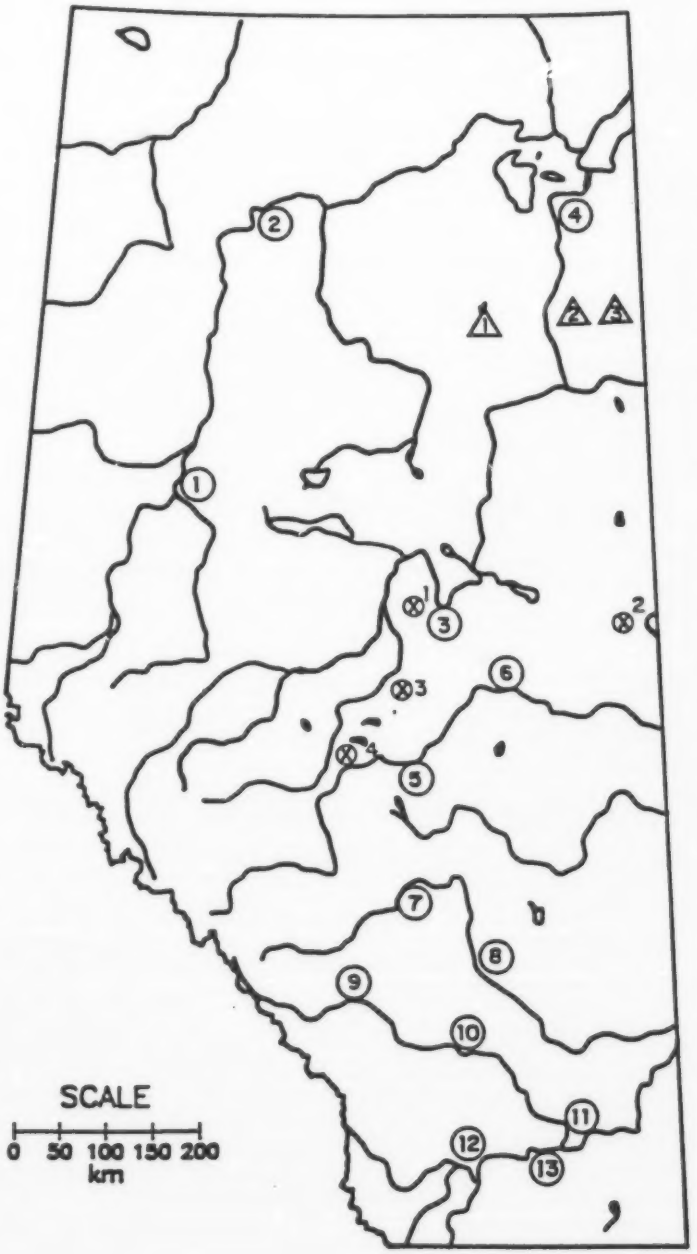

LONG-TERM RIVER NETWORK

1. SMOKY RIVER AT WATINO
2. PEACE RIVER AT FORT VERMILION
3. ATHABASCA RIVER AT ATHABASCA
4. ATHABASCA RIVER AT OLD FORT
5. NSR AT DEVON
6. NSR AT PAKAN
7. RED DEER RIVER AT RED DEER
8. RED DEER RIVER AT MORRIN
9. BOW RIVER AT COCHRANE
10. BOW RIVER AT CARSELAND
11. BOW RIVER AT RONALENE BRIDGE
12. OLDMAN RIVER AT LETHBRIDGE
13. OLDMAN RIVER AT TABER

LONG-TERM LAKE NETWORK

- ⊗ 1 BAPTISTE LAKE
- ⊗ 2 ETHEL LAKE
- ⊗ 3 NAKAMUN LAKE
- ⊗ 4 WABAMUN LAKE

NORTHERN LAKES

- △1 LEGEND
- △2 UNNAMED
- △3 UNNAMED

LONG TERM RIVER AND LAKE WATER QUALITY MONITORING SITES

FIGURE 11

MAPS
NOT
FILMED

CARTES
OMISES